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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

EDUCATION OF THE PROFESSIONAL CHEMIST[1]

IN conforming to the time-honored custom of presenting an address as retiring chairman of Section C, it occurred to me that I might not select a subject more worthy of thoughtful consideration than the education of the professional chemist. In view of the fundamental changes in conditions throughout the commercial world, affecting educational institutions by bringing forward aspects of mental training and practical applications that have no precedents in our earlier experience, it is certainly essential that this influence on modern progress receive critical attention. The recent excellent papers expressing the views of eminent teachers and practical chemists on suitable requirements for the training of young men in chemistry have ably presented the various aspects of this important subject. Yet I have thought that the last word has not been said concerning certain features of professional education, especially relating to the mental attitude of the student, and of the embryo chemist about to enter business life. It can not be doubted that the courses offered by schools of science deserve all the attention they have received in the form of suggestions and criticisms, particularly from the experience of older graduates gained in close touch with great operations in the industrial world. The

[1] Address of the vice-president and chairman of Section C, New York meeting, December, 1906.

term professional chemist is suggested to include the chemical engineer, the engineering chemist, the expert and the consulting chemist.

Even those of us who have been actively occupied in the broad field of chemistry as teachers or professional workers during the last quarter or third of the century, find it difficult to realize the great transition within this period. It is inevitable that the all-pervading commercial spirit of our generation should be felt in institutions of learning, perhaps more forcibly in schools of science, where students have an immediate prospect of seeking their fortunes in the absorbing vortex of business activity. The benefits that have come to those institutions as one result of the recent unparalleled industrial and business expansion have been accompanied by certain disturbing influences that are difficult of control. With such a golden flow into the educational coffers, new institutions have grown to large proportions like the traditional mushroom, and the older ones have doubled or quadrupled in capacity and power.

Naturally, every student within college walls has his attention attracted to the courses of wealth which provide these great benefactions. It suggests a possibility of a similar pecuniary reward even to the extent of limiting his interest to subjects and their especial features that shall in his estimation lead to immediate advancement and profit on his exit from the collegiate environment. I believe I am stating a part of the common experience of teachers, with reference to the mental attitude of a considerable proportion of the student body. Impatient of attainment along the lines of self-improvement and broad culture, the student regards his institution merely as an influence in gaining an initial foothold, satisfied with the minimum requirements that it will accept for his respectable graduation. I do not wish to express the belief that this feeling is universal, but it is sufficiently evident both as to outward expression on the part of some, and through the influence of association on the part of many, to interfere seriously with the highest ideals of intellectual training. It tends to limit the efforts of teachers to a monotonous routine, and the maintenance of an acceptable standing of students in this routine.

It can not be doubted that the conditions of instruction in the highest institutions may be greatly improved by certain changes in the secondary schools. Much has been done within the last few years mainly with the aid and cooperation of teachers in the higher institutions; but the suggestions for better work in chemistry have been limited rather to improvement in methods already in use than to fundamental changes to eliminate primary causes. Judging from the results of entrance examinations, the pupil is taught a text-book rather than chemistry, a fatal error with young pupils, for when they once begin to depend on the printed page, their vision of what they should learn is obscured by their false support. Observation of natural facts should be the only guide until the pupil has a sufficiently well-grounded method to enable him to distinguish between his own observation and printed descriptions. On account of the inherent inertia of young pupils and their inclination to lean on the teacher or the text-book, it is not safe to permit the use of a book until they have acquired a good knowledge of facts and deductions.

Why chemistry should be relegated to the fourth year of the high school, and then suddenly launched on the pupil as a full-fledged science, usually prefaced, as in the ordinary text-book, with a series of definitions and a statement of theoretical principles, almost before the correct obser-

vation of a single fact, it is difficult to understand. I believe the reason usually suggested is that chemistry can not be taught to immature pupils of the lower grades. With the text-books at present in use, I appreciate the force of this suggestion, and it applies with the same weight to the grade to which it is introduced, the third or fourth year of the high school. At the age of most susceptible inquiry the child is in an environment in which he is constantly confronted with chemical changes, yet he is permitted to know nothing even of the air he breathes, or the water he drinks, except that the former is hot or cold, and that the latter quenches thirst, until he reaches the age of fifteen or sixteen years. At this period, having spent one third or more of his time on arithmetic and higher mathematics, and the remainder in text-book drill on other subjects, his mind has lost to a large extent the elasticity of earlier years, and he naturally attacks any new subject by the same routine methods. It may easily be demonstrated that correct habits of observation and inference in chemistry and certain elementary facts that every person should know can be taught in the grammar grade. The pupil whose school life terminates with the grammar school may demand as his due that he shall receive such instructions. His capacity is fully equal to it; it is necessary with whatever department of business he may be connected; it is one of the most important elements of his education. Why should he not have it? No extensive laboratories are needed; no expensive apparatus. The expense is but a trifle. But it does demand the teacher; one who can put aside the text-book, and present chemical changes from nature's standpoint; one who has the aptitude to lead the youthful mind from the simple observations of every-day life to less obvious chemical changes, until before the pupil is aware of it he has acquired the habit of thought essential to the proper study of elementary chemistry. I grant that the latter requirement is the most difficult of all; but it is one of the pressing needs to place instruction in the grammar grade on a sensible basis; teachers properly trained to teach the elementary facts of nature. With such a foundation the high-school course may be made more effective, and it should then properly be assigned to the maturer years. It should include a comprehensive study of facts and elementary reasoning, but with limited theoretical conceptions, which should be left to the broader courses of the higher institutions.

Teachers of large experience who are fortunately in touch with the details of manufacture in large plants, have a vivid sense of the marvelous expansion that is in progress all over the world and especially in our own country. While the practical chemist must know something of all the important branches of manufacture, it is beyond his capacity to acquire a working knowledge of more than a limited range of processes, and to keep pace with the advance in improvements. The outcome of this situation is the intense specialist, one who not only knows what is common knowledge of his subject, but who has carried his study and application beyond the border. This sort of man is in active and increasing demand; his service is much sought for, and he can command his remuneration. The successful man of business, especially the chemical manufacturer, is of necessity a specialist in his particular field. He is keenly alert in acquiring knowledge of new advances. But in the many ramifications of his business, he often finds himself beyond his depth, and it is here that he appreciates the service of the broadly trained man. As never before, successful manufacturing operations

are dependent on the application of scientific principles in a scientific manner. Such a position promises most to the young chemist, and the sooner he comprehends its possibilities the more rapid will be his promotion. When he steps out into the great school of active life, so far as his practical knowledge of details are concerned, he should understand in all modesty that he must begin at the lowest round of the ladder. While gaining his business experience and patiently waiting for the opportunities, which will not be long delayed, when his scientific attainments shall be called into service, he will escape the criticism frequently made by manufacturers that the young graduate is apt to assume a grasp of practical details that he has not acquired.

Most manufacturers have a high respect for the advantages afforded by scientific education, and are ready to receive the young graduate with open cordiality, expecting service that they stand in need of. With too great confidence in his grasp of practical details, often the manufacturer assigns duties involving business experience which the young man has yet to gain, with disappointing results. In thus rashly undertaking such work he not only brings discredit on himself, but arouses a feeling of distrust concerning the practical utility of scientific training in general.

It may, perhaps, be said of the professional chemist that his career depends in no small degree on ancestral inheritance. I am inclined to the belief that this is true with reference not only to inborn energy and ability without which the best success is not possible in any direction, but especially to a certain inherent quick perception and logical turn of mind, that many persons do not possess and can never acquire. Certain it is that no amount of training can produce a successful chemist out of an individual who lacks these essential qualities. An extended experience in fitting young men for employment in chemistry leads, I think, to the conviction that it is not a large proportion of the average body of students that have the peculiar mental poise and manual dexterity to become successful chemists in a broad sense. As to what should be regarded as success, pecuniary compensation may in general be accepted as a measure of ability, although many men in responsible positions will not accept such a standard since they feel that their service is not recognized in proportion to the profits they help to accumulate in the business treasury. Generally speaking, however, with the unprecedented demand for good men, ability is well compensated. With respect to young men just gaining a foothold there is evidence that their service is appreciated. Statistics have recently been collected from graduates of five years' standing from Case School of Applied Science in all departments, with reference to what salaries would induce them to accept other positions on the basis of what they are now receiving. The average in chemistry was $3,000. After ten or fifteen years of service, I have reason to believe that salaries of professional chemists equivalent to $5,000 and $10,000 a year are not uncommon. While the standard of pecuniary compensation is not unreasonable from the point of view of the man of business, who looks on his ledger balance at the end of the year as a measure of success, the professional chemist seeks also a higher reward. He can not sever his mental connection from the profound truths of nature, and the more he struggles for the mastery and utilization of those truths, the deeper becomes his reverence for the immutable laws that control and direct his efforts. He is constantly under the stimulating influence of new discovery and an expanding field of usefulness. It

is, perhaps, unnecessary to suggest that this does not apply to the man who is content with a daily routine, with no connections outside of his laboratory walls, but, as mentioned above, to one who is equal to present demands; who is alive to the advance of knowledge in his particular field the world over; who is able to keep in touch with new applications and new processes, and to apply them with discretion. To such a man, imbued with the spirit of research and the instinct of successful application, the best reward for unselfish effort is its appreciation from the point of view of professional standing, which even the manufacturer, after he is assured that the ledger balance is satisfactory, is eagerly ready to recognize.

An incidental advantage to the professional chemist, one of the features of his education, is the readiness with which he is able to grasp the essential principles of business operations. I have been impressed by the frequent expressions from older graduates as to their feeling of indebtedness to a chemical education for success in the application of business methods. They recognize the fact that the close observance in experimental study, constant exercise in inductive reasoning, and the consequent truthful attitude of mind, the directive forces in the study of chemistry, establish in the individual the habit of looking at all matters that concern him from a similar point of view.

If this be the situation that confronts the young graduate when he enters business life, what shall be his preparation for the duties that await him? What is the responsibility of the institution that sends him forth? First of all, he must be a well-balanced man physically and mentally, alert to the individual duties of life. The best success in any department of activity depends primarily on the service of a well-nourished, healthy body, and such health and strength is dependent on the observance of correct habits of bodily attention and nutrition, established in early youth. During the critical period of school and collegiate training, it is imperative that the excessive mental strain be supported by systematic physical exercise, or the individual will suffer. It is incumbent on an educational institution to provide suitable physical exercise and to require it of every student. Man is a creature of habit, and correct habits early formed are more readily observed in later life.

In the technical preparation for professional employment, as suggested above, the education in chemistry should begin in early years in the grammar grade; correct habits of observation and reasoning should be made a part of the youthful mental equipment. In the higher institution, without interfering with the time devoted to strictly professional studies, sufficient time should be allotted to language and literature, history, philosophy and economics, to impart breadth of thought and to supplement the culture of the science courses. I am not in sympathy with the thought sometimes expressed that science and science studies do not contain the elements of culture. On the contrary, I believe that the best culture is derived from the proper study of physical science. Why should it not be? Is it reasonable to assume that all culture is limited to the study of man with his imperfections, and his works, what he has been, what he has done, excluding the perfect laws of his environment, the universe? It is evidently true that science courses alone do not lead the student to broad conceptions of his duty to society and his relations to the community, unless they are supplemented by courses, as suggested, in other departments of learning.

In the training of the professional

chemist, two facts should be kept in view. Primarily, he must understand chemical changes. Secondly, he must have the ability to devise and operate machinery and appliances in which chemical changes are to be applied on a manufacturing scale. It would seem that the tendency in some of the modern courses in chemical engineering is to give too great prominence to the engineering features at the expense of time that should be devoted to chemistry, with the production of neither an engineer nor a chemist. There is not time in a course of four years to make a good chemist and a finished engineer in the same individual; neither is it possible to make a good chemist without sufficient time and attention for comprehensive training in chemistry. But it is possible to make a good chemist and to allow him adequate time to gain such knowledge of the engineering features as will give him a good foundation for expansion when he enters the factory. In all departments of business the individual who has learned how to do things himself is best fitted to direct the efforts of others; the superintendent who can saw off a board by the square or set a post straight and true, can instantly see whether another is doing his duty. The broadly trained chemist must, therefore, have had practise in handling tools, in working wood and iron; he needs the elements of contruction, of machine design. He must understand the economic production and application of power from different sources. An important part of his equipment is the nature and manipulation of electrical currents and machinery. Such breadth of knowledge may be gained in courses on shop practise, thermodynamics, applied mechanics, heat and steam, hydraulics and machine construction, attendance on courses in electricity with laboratory practise.

In this connection the recurring question of adequate time in the ordinary course may be satisfactorily answered by the tendency in most institutions to extend the limits of practical work. In Case School of Applied Science, the entire month of June is given up to laboratory and field work as a practise term, which adds about one year of practical study to the course of four years. The student is under constant supervision, with sufficient oral instruction to keep him intelligently occupied. Continuous laboratory practise accomplishes very much more that the interrupted hours of the other terms. In answer to the possible objection that it is some infringement on the time for lectures and recitations, it is true that two or three weeks a year are lost to these exercises; but what is gained in practical application in chemistry makes it about equivalent to a course of five years, and the average student is easily able to accomplish the work mentioned above in mechanics and electricity. Indeed, before this recent change in the additional time devoted to the laboratory, our best students and even those of average ability by dint of hard work were able to finish this course. With no sacrifice, therefore, of necessary training in chemistry, the student receives what is needful when he enters on the practise of his profession. Such a course may be designated as engineering chemistry, in which the student becomes primarily a chemist.

To acquire an adequate grasp of foundation principles in chemistry it is necessary to include thorough comprehensive courses in general, inorganic, analytical, theoretical and physical, and organic chemistry, with much time devoted to laboratory work. This routine is practically the same in all institutions, with increasing attention to experimental physical chemistry. It seems scarcely necessary to allude to the subsidiary subjects: English, modern lan-

guages, mathematics, including calculus, descriptive geometry and drawing, physics, mineralogy, elementary use of surveying instruments, and metallurgy, without which a course in engineering chemistry could not be regarded as complete. The increasing importance of bacteriology in the fermentation industries and sanitary chemistry, render it indispensable that the student have some practise in the manipulation of bacteria, and general use of the microscope. He must understand the composition, methods of analysis, valuation and uses of solid liquid and gaseous fuels, and the methods of heating and lighting. In the work of the fourth year, it is essential that the student be led to some extent at least out of the routine of the previous years, to develop greater self-reliance, and to be brought into somewhat close touch with chemical literature, to establish the habit of ascertaining what has been done in any special line of work before undertaking it himself. It is important that he gain a clear understanding of the proper methods of attacking new problems and that he appreciate the necessity of depending on his own resources. In the ordinary course of four years the time that can be devoted to such study is much too limited, but it should be insisted on to the fullest possible extent. The atmosphere of the laboratory should have the stimulating influence of original research. If students feel that they have something before them besides the routine courses it keeps them up to their best effort; they quickly perceive the difference between the spirit of an instructor who has no ambition beyond the hourly recitation and that of one imbued with enthusiasm of original study, and eager to impart something of his own impulse.

Since the chief aim is the preparation of the chemist for efficient service in the manufactory, an essential feature of our discussion relates to the method of teaching industrial chemistry. Evidently in a well-balanced course this instruction should be preceded by the routine work of the first three years, general, analytical, physical, and organic chemistry, all of which is a necessary preparation. Since there is at present nearly as great a demand for men in positions where organic chemistry is requisite as in places which concern inorganic processes alone, the student must be well grounded in theoretical and practical organic chemistry, when undertaking industrial chemistry. I have found it an excellent plan to carry along the course of organic industrial chemistry in the same term with lectures and laboratory practise in organic chemistry. Every operation in applied chemistry is so closely attended by physical conditions affecting economic results, it is necessary that attendant conditions of processes be kept constantly before the student. As one of numerous examples that may be suggested, vapor tension, heat of solution, vaporization, specific heat, are closely connected with distillation, solution, crystallization and purification.

The schools of science owe their foundation primarily to the labors of self-educated men, who without the advantages of systematic training have devised and perfected on a business basis the fundamental methods of the factory. In taking up the burden of his forebears the young graduate is expected to extend it with the advance of modern demands. Shall the school of science attempt to duplicate in a miniature fashion the factory methods with suitable machinery and appliances, or shall its efforts be directed toward broad training in fundamental principles with such laboratory applications as are needed to comprehend an expansion to a manufacturing scale? Evidently this question should be considered from several points of view. It

must be remembered that application on a laboratory scale of any manufacturing process in a manner to afford satisfactory results needs more time than can be found for it in the course of four years, unless it be taken as a subject of a thesis when sufficient time may be devoted to a single subject. But general application should include a considerable number of processes. Depending on the nature of the process, not less than two weeks to two months must be exclusively devoted to any important single operation, and the benefit derived is limited mainly to this process. Another serious hindrance is the magnitude of an adequate equipment. A separate plant of two or more buildings is needed, for the dust and dirt of one variety of process could not be tolerated in the cleanly conditions necessary in others. With sufficient equipment a graduate course should afford ample time for such work on a broad plan. Such a course should evidently include a study of details and conditions with reference to possible improvements. It can not be doubted that an adequate equipment in teaching force and plants working in conjunction with manufacturing establishments, and with sufficient endowment for the costly operation, should form the basis for the expansion of a profitable graduate course. A school of science fortunately situated in the midst of a great variety of manufacturing operations has the immense advantage that the manufacturing plants really constitute an important adjunct to its equipment. After thoroughly reviewing the details of a manufacturing process in lectures and recitations, next to actually conducting the operation, the student receives a part of his most valuable experience in inspecting such operation under intelligent guidance during his visits. It is a mutual advantage to the institution and to the manufacturer, for it is an invaluable aid to the courses of instruction in the former, and it insures to the latter a more practical knowledge of processes to the student whom he may later employ.

With the most elaborate experimental preparation, however, the graduate approaches a different atmosphere when he enters the factory where every effort has a pecuniary value. Outside the factory it is not possible to take into account the element of costs, which is the controlling principle in any business. It is easy to ascertain the market values of crude materials and finished products, but the long array of numerical details intervening which constitute the business of manufacture is a closed volume to every one outside the counting room. The guiding thought of the student is the acquisition of accurate knowledge of principles and methods. The chief aim of the manufacturer is to apply those methods in such a manner that the pecuniary results may be entered on the right side of the balance sheet in the shortest possible time. As an example of this difference in motive it is often suggested that students in quantitative analysis be given practise in rapid application of methods; but the fact is forgotten that the student is fully occupied in the attainment of accuracy, and that rapidity is soon acquired. It may take him a day or two to master the necessary dexterity in applying the method for the determination of phosphorus in a single sample of steel. When he goes out into the factory laboratory he may be required to hand in results on thirty samples in a single day. This distinction seems to be best expressed by the difference in environment; the student acquires his knowledge in the quiet atmosphere of the educational institution; the man of business applies his knowledge under the stress of manufacturing conditions.

The service of the school of science for the benefit of the community is well established, but it has not yet secured the tenacious hold of the older college, which, in educating generation after generation, father and son, has established the traditions of the family on scholarship and culture, and extended the influence of collegiate training into the professional and business world. The first generation of graduates from the scientific school has had barely time to make its record, but an honorable record is assured, and it will be continued by their sons and grandsons. Traditional family support of an institution is one of its most valuable assets intellectually and pecuniarily; fortunate is the institution that has this support in the best families.

The school of science in its breadth of training and scope of applications is peculiarly an American institution. In England, until recently, the spirit of progress along similar lines has been somewhat inactive. But aroused by the recent great industrial activity to the fact that their old-time plants must be rehabilitated and that our young men are being called on for assistance, large grants have been made to establish schools of science, and the managers of these funds are inquiring with much interest into the foundation and operation of our scientific institutions. The fact is being recognized that the business world is receiving aid from practical methods that they must adopt to regain their industrial standing.

In Germany the conditions are essentially different. While the labors of the early French and English investigators contributed very largely to the foundation of chemical science, our immediate inspiration came from the German laboratory. More recently the unprecedented expansion of our national resources has developed circumstances so fundamentally different, our institutions have of necessity directed their efforts toward meeting business requirements to the extent that they are unique. Yet the atmosphere of quiet scholarly inquiry of the German institutions still retains its influence. The great body of German scholars in happiness and contentment devote their lives to discovery and elaboration with sufficient remuneration for economical living and simple habits, and the world is benefited by their labors. In the great manufactory such as that of the Badische Aniline Fabrique or of Meister, Lucius and Bruening hundreds of chemists are employed, a large proportion with doctorate degrees from the universities. Those men are devoting their best efforts to the interests of their employers in the national spirit of faithful application and with very moderate compensation. If such establishments were compelled to pay salaries equivalent to those granted for similar service in our own factories, it would doubtless make a serious inroad in the very generous dividends they are now able to declare.

It is extremely doubtful whether the conditions in the German university, including their long vacations, their leisurely habits during the semesters, and with no restraint on the student except attendance at final examinations, are applicable in American schools of science. Certainly their traditional method of allowing the student, whatever his capacity, to work out problems on his own resources, even before he is well grounded in breadth of practical methods, could not meet our requirements.

I am sure there will be no dissent from the view that original research is of equal importance in the school of science as in the university, although evidently it should take a somewhat different form in the scientific institution. In the university labo-

ratory, research has for its object the advancement of knowledge with no visible practical utilization. The same spirit must pervade all research; that is, its foundation rests on the principles of pure science. In the scientific school the great field includes the application of the principles of pure science to the solution of commercial problems. To one who is conversant with the conditions in the manufacturing plant that lacks the aid of men skilled in science it is evident that much of the work is the result of disconnected observations loosely made in a rule-of-thumb fashion, rather than the outcome of systematic study of underlying principles with expansion to methodical application. There is urgent need of the extension in all directions of the critical comparison of methods of analysis and testing which has made such a good beginning. To appreciate the importance of this work it is only necessary to glance at the want of concordance in the results of analysis of a given substance even from the best laboratories. The recent establishment of the national bureau of standards is an excellent foundation for greater accuracy and closer agreement in the results of different workers.

The education of the professional chemist is concerned in the recent discussion on the relations of the scientific school to the university, and the cogent reasons suggested for its rehabiliment as one of the professional departments with law, medicine, etc. If such a change were feasible doubtless scientific education should proceed along much the same lines, for the seeker after its benefits could not otherwise secure his training, and the instruction would of necessity conform to the demands of business. The endowment of other schools of science is not probable; the present tendency is rather to expand scientific training in institutions already established. This is especially true of the state universities, in some of which the best practical training in science is given. The permanency of those institutions in their reliance on the state gives promise of the broad development of practical science. What may be said in this direction relates, therefore, to a comparatively few institutions, and it evidently applies to a few conditions concerning which there are doubtless differences of opinion—culture, educational atmosphere, policy of management, economy in resources. That the student of applied science should gain in culture and breadth of thought in the university atmosphere may be true with corresponding changes in his work; but the strictly professional training can not be abbreviated, and it is believed that culture should be imparted in these courses as now conducted in the scientific institution. As to whether the university atmosphere is well adapted to the close application and vigorous effort required in the school of science, may be questioned. Besides certain small economy in office supervision, it does not appear that any important reduction in running expense is possible. There is a limit to the number of students in a single recitation or laboratory division. A given number of students in the scientific school needs the same number of teachers and the same equipment as in the university.

In respect to policy and administration it would seem that the school of science has an essential advantage over the professional department in the university. The head of the scientific school devotes his best thought and energy with an intense personal interest to his institution. Such devoted service from a president thoroughly imbued with the scientific spirit, with such expert knowledge and force of character that his word has carrying power with the public and with governing boards as well as with-

in the institution, and with business instincts that enable him to meet men of affairs on grounds of mutual interest and understanding, must of necessity be more efficient than that of the dean who is interested in his department as one element of a great university, not wholly independent in applying his convictions nor untrammeled by other considerations incident to his department. It is no doubt true that the conditions affecting the school of science in its relations to the business world are essentially different from those of law and medicine, as integral elements of the university.

With reference to a combination in resources which is the chief source of strength in the great modern business corporation and its application along similar lines in the university, the successful element in the manufacturing corporation is the elimination of manual labor with its uncertainties and imperfections, and its more general displacement by machinery that is invariable in its operation. It is admitted that without the larger substitution of labor by machinery, the same efficiency and economy are not secured in manufacturing plants in which details are altogether in the hands of salaried employees, as was possible in the earlier period when smaller branches of business were under the direct personal supervision of the owners. On the other hand, in the educational field, mind is the immediate controlling and directing power in every detail, with no intervention of mechanical appliances. The teacher can not direct his students and carry on his instruction from a distant city, or from another continent.

The essential principle of combination in business, that modern conditions demand great accumulations of capital and resources for control in competition and commerical fluctuations, does not apply in a similar degree to any successful educational institution, for there is a far greater demand for graduates than can be supplied, and there is little difficulty in securing necessary funds for carrying on fundamental lines of educational work. If it be true, as has been stated, that the German universities are much overcrowded with respect to employment after graduation, and that strenuous efforts are put forth through German residents in this country to place their graduates here, the element of competition is not wanting, or may not be in the immediate future. Such competition may even be a stimulating advantage, inciting the workers here to greater effort. Already we have cause for congratulation in the standing of our research laboratories, especially in physical chemistry. It is an indication of a leading position in research and the advancement of knowledge to which the devoted labors of the numerous able investigators in this country during the last thirty years have contributed. A powerful aid, which it is all too soon to appreciate in its desirable results, is the immense funds for research recently established. Although primarily these grants are made in furtherance of work in pure science, evidently applied science and professional chemists will be greatly benefited. Perhaps the wisest grant of all is the Carnegie foundation for the retirement of teachers, for in a measure it relieves the teacher during his earlier years from the anxiety of later need, and gives him courage to devote his residual energy in some efforts for the advancement of knowledge. Every institution named in this grant is benefited in its standing, for it may insist that applicants for positions have adequate training for research, and that their ambition lie in that direction.

In the changes in business management during the last decade, and the transfer of business control from private ownership to

great corporate bodies in which the vested property rights have passed into possession of the general public by the distribution of shares and bonds, there is an indication of a tendency toward the creation of a class distinction in labor as well as in property control. It is not at present so apparent in its results as it will doubtless appear later when the very prosperous conditions of business and consequent increase in private fortunes and lavish expenditure shall inevitably be affected by enforced economy of a more stringent commercial situation. At present all forms of labor are employed with increased compensation and with a serious deficiency in many directions. But there is an evident tendency toward a lower valuation of mere manual force and an increased valuation of mental agency. In corporate control success depends, in some directions altogether, on the personal qualifications of a superintendent or manager, and the right sort of men are much sought for and difficult to secure. The pressing need is for managers of executive capability for manipulating men and methods, and it has developed so suddenly, it is all too soon for the production of an adequate supply. A great business corporation can be created in a day; but years are necessary to produce men who can manage its departments.

Class distinction in labor will appear in the elevation of skilled labor, the thoroughly trained man of science of executive ability, and the manager, and the degradation of brute force as it is embodied in the individual whose possession consists only in what nature has conferred on him. What will become of the latter as the labor of his hands is more and more completely replaced by machinery that can do his work better, is one of the great problems of the future. It will be a question of the survival of the fittest, and one that has a lively interest for the youth who is now deciding what his future shall be, for this, and other similar phases of social and industrial life, will be brought prominently into view during his generation.

A feature of modern progress that has an intense personal interest to every individual in active business life is the tenure of activity. Formerly the connection with affairs of business was coincident with life itself. But the old-time methodical, slow-moving habits of the last generation of business men whose attendance in the counting-room included the daily working hours, has given place to close connections by telegraph, telephone, limited trains and other inventions that tax human endurance. The father attended to his correspondence, writing all his letters; the son takes up a pen only to sign checks and documents. The youth of the present day must amass his fortune, make his reputation, get his enjoyment and pleasure in business affairs and be ready to resign his place to another at the age of fifty or sixty years, at just the period of life when the normal man should be in his prime, and able to render his best service by reason of his experience and mature judgment. This is a serious limitation for young men who have spent eight years or more of their lives in gaining an education, although the graduate of the school of science has an advantage over those who select other professions that require three years or more of additional preparation, which with subsequent office practise render it scarcely possible for the young lawyer or doctor to start out in business for himself much before the age of thirty years. In taking a position immediately after graduation in the manufactory, the man of science is making his way while he is gaining his business experience. Ten or fifteen years at least are necessary to develop the productive capacity of any man; and the remaining few years permitted to

him for accumulation demand the utmost concentration of effort. What will be the result of this intense strain, and the effects of such a time limit on what the average man hopes to accomplish, can only be ascertained by future observation. But the situation is inevitable, and the young man is wise who heeds for his future the counsel and experience of his elders.

It would seem that these various influences have an important bearing on the present and future conditions of practical education in determining what the student may expect who seeks a suitable preparation for the profession that will absorb his best energies and that shall constitute his life-work. It is of less consequence where he is educated, provided he attains the mental poise and attitude that enable him to grasp fundamental truths and to apply them correctly in the accomplishment of great undertakings.

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CASE SCHOOL OF APPLIED SCIENCE

SECTION K—PHYSIOLOGY AND EXPERIMENTAL MEDICINE

SUMMARY OF THE PROCEEDINGS

THERE were three meetings of the section during convocation week.

The first session was convened on Thursday, December 27, at 2:15 P.M., at the College of Physicians and Surgeons, in the presence of an unusually large audience. At this meeting the officers for the year 1907–8 were elected; the retiring chairman, Professor William T. Sedgwick, delivered the annual address; and a symposium was held on the subject of 'Protozoa as Factors in Disease.'

The second session was held on Friday, December 28, at 10 A.M., at the Rockefeller Institute for Medical Research, in affiliation with the Society of American Bacteriologists. Twelve papers were presented.

The third session was held on Saturday, December 29, at 10 A.M., at the Rockefeller Institute for Medical Research, in affiliation with the American Physiological Society. Sixteen communications were offered.

EXECUTIVE PROCEEDINGS

The following officers were elected for 1907–8:

Vice-president and chairman of the Section—Ludvig Hektoen.

Secretary—William J. Gies.

Sectional committee—Simon Flexner, vice-president, 1906–'07; Ludvig Hektoen, vice-president, 1907–'08; William J. Gies, secretary, 1905–'08; Charles S. Minot (one year); J. McK. Cattell (two years); Frederick G. Novy (three years); Graham Lusk (four years); Jacques Loeb (five years).

Member of the Council—S. J. Meltzer.

Member of the General Committee—Edward K. Dunham.

SCIENTIFIC PROCEEDINGS

Program of the First Session, December 27, 1906

Vice-presidential address—'The Expansion of Physiology': William T. Sedgwick. (Published in SCIENCE, this volume, page 332.)

Symposium on Protozoa as Factors in Disease:

Introductory remarks by the chairman: Simon Flexner.

'The Protozoa from the Standpoint of the General Naturalist': Edmund B. Wilson.

'Some General Principles in connection with Protozoa as Factors in Disease': C. W. Stiles.

'The Protozoan Species': Gary N. Calkins.

'The Morphological Diagnosis of Pathogenic Protozoa': James Ewing.

'Immunity against Trypanosomes': F. G. Novy.

General discussion by William H. Welch, Henry B. Ward and James Carroll.